California Air Resources Board

Greenhouse Gas Quantification Methodology for the Department of Forestry & Fire Protection (CAL FIRE) Urban and Community Forestry Program

Greenhouse Gas Reduction Fund
Fiscal Year 2016-17

November 23, 2016

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Section A. Introduction

The goal of California Climate Investments is to reduce greenhouse gas (GHG) emissions and further the purposes of the Global Warming Solutions Act of 2006, known as Assembly Bill (AB) 32. The California Air Resources Board (ARB) is responsible for providing the quantification methodology to estimate the net GHG benefit and other benefits from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF). ARB develops these methodologies based on the project types eligible for funding by each administering agency as reflected in the program Expenditure Records available at: https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/expenditurerecords.htm. ARB staff periodically review each quantification methodology to evaluate its effectiveness and update methodologies to make them more robust, user-friendly, and appropriate to the projects being quantified.

For the California Department of Forestry & Fire Protection's (CAL FIRE) Urban and Community Forestry (UCF) GGRF Program, ARB staff developed this quantification methodology and Urban and Community Forestry GHG Calculator Tool to provide methods for estimating net GHG benefits of each proposed project (Section B), provide instructions for documenting and supporting the estimate (Section C), and outline the process for tracking and reporting GHG and other benefits once a project is funded (Section D).

This methodology uses calculations to estimate carbon sequestration in planted trees, GHG emission reductions from the effects of tree shade on building energy use, carbon stored long-term in wood products, avoided GHG emissions from the displacement of fossil fuels resulting from utilizing biomass for electricity generation, avoided GHG emissions from preventing the landfilling of biomass, and GHG emissions associated with the implementation of UCF projects. Projects will report the total project GHG benefit estimated using this methodology as well as the total project GHG benefit per dollar of GGRF funds requested.

Urban and Community Forestry Project Types

CAL FIRE developed three project types that meet the objectives of the UCF Program and for which there are methods to quantify a net GHG benefit. Other project features may be eligible for funding under UCF Program; however, each project requesting GGRF funding must include at least one of the following project components for FY 2016-17:

- Tree planting
- Biomass utilization for wood products; and
- Biomass utilization for electricity generation.

Section B of this quantification methodology details the methods to use based on the project component(s) proposed.

Methodology Development

ARB and CAL FIRE developed this quantification methodology consistent with the guiding implementation principles California Climate Investments, including ensuring transparency and accountability.[1] ARB and CAL FIRE developed this quantification methodology through a public process to be used to estimate the outcomes of proposed projects, inform project selection, and track results of funded projects. The implementing principles ensure that ensure that the methodology would:

- Apply at the project-level;
- Provide uniform methods to be applied statewide, and be accessible by all applicants;
- Use existing and proven tools and methods;
- Use project-level data, where available and appropriate; and
- Result in GHG emissions-reduction estimates that are conservative and supported by empirical literature.

ARB reviewed peer-reviewed literature and tools and consulted with experts, as needed, to determine methods appropriate for the UCF project types. ARB also consulted with CAL FIRE to determine project-level inputs available. The methods were developed to provide estimates that are as accurate as possible with data readily available at the project level. ARB released a draft FY 2016-17 quantification methodology for public comment in October 2016.

Tools

This quantification methodology and the UCF GHG Calculator Tool rely on project-specific outputs from one of two U.S. Department of Agriculture Forest Service (USFS) urban tree carbon accounting tools:

The Center for Urban Forest Research (CUFR) Tree Carbon Calculator (CTCC) provides quantitative data for individual trees to be planted as part of the project including the amount of carbon stored, the estimated effects of tree shade on building energy use, and the dry weight of aboveground biomass based on project characteristics such as the climate zone, tree species, tree age or diameter at breast height (DBH), and tree location relative to a building. The CTCC can be downloaded from: http://www.fs.usda.gov/ccrc/sites/default/files/Carbon_Calculator.zip. A user guide and help menu is included along with the tool once the CTCC is downloaded. The spreadsheet also provides cell-specific definitions and assistance.

The USFS i-Tree Streets software tool which provides quantitative data for an entire population of urban trees to be planted as part of a project including the amount of carbon stored and the estimated effects of tree shade on building energy use based on project characteristics such as the climate zone, tree species, and tree DBH. i-Tree

[1] As described in Volume 1 of the Funding Guidelines.

Streets can be downloaded from: https://www.itreetools.org/. A user manual for i-Tree Streets is available from:
https://www.itreetools.org/resources/manuals/Streets_Manual_v5.pdf.

Applicants must use this quantification methodology, in conjunction with the accompanying UCF GHG Calculator Tool, to estimate the net GHG benefit of the proposed project. The UCF GHG Calculator Tool can be downloaded from: https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/quantification.htm.

Major Updates

ARB updated this quantification methodology from the previous version.[2] The major changes include:

- Required use of this standardized quantification methodology;
- Inclusion of an additional U.S. Department of Agriculture Forest Service (USFS) urban tree carbon accounting tool, i-Tree Streets, for the purpose of estimating carbon storage and building energy savings;
- Addition of tree mortality rate;
- Addition of avoided emissions from the landfilling of biomass;
- Addition of method to estimate emissions from project implementation;
- Development of an accompanying GHG Calculator Tool to assist with quantification; and
- Addition of information from the approved ARB Funding Guidelines for Agencies Administering California Climate Investments (Funding Guidelines)[3] on reporting after a project is selected for funding (see Section D for details).

Program Assistance

CAL FIRE staff will review the quantification portions of the UCF project applications to ensure that the methods described in this document were properly applied to estimate the net GHG benefit for the proposed project. Applicants should use the following resources for additional questions and comments:

- Questions on this document should be sent to GGRFProgram@arb.ca.gov.
- For more information on ARB's efforts to support implementation of GGRF investments, see: https://www.arb.ca.gov/auctionproceeds.
- Questions pertaining to the UCF Program should be sent to the CAL FIRE Urban Forestry Advisor nearest to the proposed project location. Contact information for Urban Forestry Advisors can be found at: http://calfire.ca.gov/resource_mgt/resource_mgt_urbanforestry_advisors.

[2] Greenhouse Gas Interim Quantification Methodology for the California Department of Forestry & Fire Protection (CAL FIRE) Urban and Community Forestry Program, Greenhouse Gas Reduction Fund, Fiscal Year 2014-15

[3] California Air Resources Board. Funding Guidelines for Agencies Administering California Climate Investments. December 21, 2015. https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/arb-funding-guidelines-for-ca-climate-investments.pdf

Section B. Greenhouse Gas Quantification Methodology

Overview

This quantification methodology accounts for carbon storage in planted trees, energy savings from the benefits of tree shade, carbon stored long-term in wood products, avoided GHG emissions from the generation of electricity from biomass, avoided GHG landfill emissions from the utilization of biomass, and the GHG emissions associated with the implementation of UCF projects. In general, the net GHG benefit is calculated using the following approaches:

Table 1. General Approach to GHG Quantification by Project Component

Tree Planting
Net GHG Benefit = carbon storage in planted trees – carbon in planted trees not assumed to survive[4] *+ GHG reductions from energy savings from shade – GHG emissions from tree planting and maintenance*
Biomass Utilization for Wood Products
Net GHG Benefit = carbon stored long-term in wood products + avoided GHG emissions from landfills – GHG emissions from mill
Biomass Utilization for Electricity Generation
Net GHG Benefit = avoided GHG emissions from displaced fossil fuel energy + avoided GHG emissions from landfills – GHG emissions from biomass facility

[4] This methodology applies a 3% annual tree mortality rate to the years after the period of establishment care (including replacement) provided by the project through year 10, at which time tree mortality is substantially reduced. This assumption is based on USFS publications and personal communication with John Melvin, State Urban Forester, CAL FIRE (April 19, 2016).

Applicants will follow the steps outlined in Figure 1 to estimate the net GHG benefit from the proposed project. Detailed instructions for each step are provided on subsequent pages.

Figure 1. Steps to Estimating Net GHG Benefit

Step 1. Identify the Project Component(s) and Appropriate Methods for the Proposed Project

Step 2. Determine the UCF GHG Calculator Tool Inputs Needed

Step 3. Determine the Project-Specific Information Needed for the CTCC and/or i-Tree Streets

Step 4. Enter Project-Specific Values into the CTCC and/or i-Tree Streets

Step 5. Estimate the net GHG benefit for the proposed project using the UCF GHG Calculator Tool

Step 1: Identify the Project Component(s) and Appropriate Quantification Methods for the Proposed Project

For GHG quantification purposes, eligible UCF projects consist of five potential project components. Applicants may incorporate more than one project component and can use multiple methods identified in this quantification methodology, as appropriate, to quantify the net GHG benefit. Applicants must identify the project components from Table 2 that apply to the project. The project components identified will determine which subsections of this quantification methodology and sections of the UCF GHG Calculator Tool must be used in order to estimate the net GHG benefit.

Table 2. Project Components and Appropriate Quantification Methods

Project Component	Method Subsection References
Tree planting	Step 2 Step 3.A Step 4.A Step 5
Biomass utilization for wood products	Step 2 Step 3.B Step 4.B Step 5
Biomass utilization for electricity generation	Step 2 Step 3.B Step 4.B Step 5

Step 2: Determine the UCF GHG Calculator Tool Inputs Needed

Table 3 identifies the required data inputs needed to estimate the net GHG benefits for proposed projects with the UCF GHG Calculator Tool by project component. The UCF GHG Calculator Tool requires different inputs for projects with tree planting components depending on which urban tree carbon accounting tool the applicant uses.

Table 3. Required UCF GHG Calculator Tool Inputs for Eligible Project Type(s)

ALL PROJECTS
General Information (Read Me worksheet) • Project Name; • Grant ID, if applicable; • Contact Name; • Contact Phone Number; • Contact Email; and • Date Completed. **Total Project GHG Benefit/GGRF $ Requested** (GHG Summary worksheet) • Total amount of UCF GGRF funds requested to implement the project; and • Total amount of GGRF funds requested to implement the project.
Tree Planting Using CTCC
Greenhouse Gas Quantification Inputs (Carbon and Energy Savings CTCC worksheet) • carbon stored in individual trees planted by the project 40 years after project start for each combination of tree and tree planting site characteristics (kg CO_2e) (from Step 4); • annual GHG emission reductions from energy savings from individual trees planted by the project 40 years after project start for each combination of tree and tree planting site characteristics (kg CO_2e) (from Step 4); • quantity of trees to be planted by the project, disaggregated by each scenario of tree and/or tree planting site characteristics; and • years of establishment and replacement care to be provided by the project
Tree Planting Using i-Tree Streets
Greenhouse Gas Quantification Inputs (Carbon and Energy Savings i-tree worksheet) • total carbon stored in population of trees planted by the project 40 years after project start (lb CO_2e) (from Step 4); • total annual electricity savings from the population of trees planted by the project 40 years after project start (MWh) (from Step 4); • total annual natural gas savings from the population of trees planted by the project 40 years after project start (therms) (from Step 4); and • years of establishment and replacement care to be provided by the project

Biomass Utilization for Wood Products
Greenhouse Gas Quantification Inputs (Wood Products worksheet) • quantity of removed trees to be utilized by the project for wood products over a 10 year period, disaggregated by each scenario of tree species and DBH or age; • aboveground biomass of each combination of tree species and DBH or age of removed trees to be utilized for wood products by the project (kg) (from Step 4); • efficiency of the mill where removed trees utilized for wood products are delivered (if not available from mill, default mill efficiencies are provided); and • percentage of removed biomass that will go into each wood product class category (if not available from mill, default wood product class is provided)
Biomass Utilization for Electricity Generation
Greenhouse Gas Quantification Inputs (Electricity worksheet) • quantity of removed trees to be utilized by the project to generate electricity via combustion over a 10 year period, disaggregated by each scenario of tree species and DBH or age; and • aboveground biomass of each combination of tree species and DBH or age of removed trees to be utilized to generate electricity via combustion (lb) (from Step 4)

Step 3: Determine the Project-Specific Information Needed for the CTCC and/or i-Tree Streets

The following subsections describe the information needed to estimate the carbon stored in planted trees (using CTCC or i-Tree Streets), GHG emission reductions from building energy savings (using CTCC or i-Tree Streets), and aboveground biomass of removed trees to be utilized (using CTCC). Applicants can choose which of these tools to use to estimate the GHG benefit of tree planting, but only the CTCC provides an estimate of tree biomass so applicants must use this tool to estimate the GHG benefit of biomass utilization. Quantification methods are provided for both tools; applicants must follow the instructions applicable to the tool selected.

A. Tree Carbon Storage and GHG Emission Reductions from the Effects of Tree Shade on Building Energy Use

Table 4 describes the information needed to estimate carbon stored in trees to be planted by the project using the two urban tree carbon accounting tools.

Table 4. Required Information for Estimating Carbon Storage

Trees species to be planted	
CTCC	**i-Tree Streets**
The CTCC includes a list of 20-30 species for each climate zone. The tool uses codes and scientific names to identify species. A complete list of species codes by climate zone with scientific and common names us available in Appendix B of this quantification methodology.	i-Tree Streets includes over a hundred species for each climate zone. The program uses codes to identify species rather than scientific or common names. A complete list of species codes by climate zone with scientific and common names is available at: http://www.itreetools.org/streets/resources/Streets Species Codes.xls

What if the tree species to be planted are not included in the tool?
If the tree species to be planted by the project are not available options within the selected urban tree carbon accounting tool, the applicant will need to use proxy species (the species that best matches the genus, size, and other characteristics of a tree to be planted) to estimate the carbon and energy benefits.

Applicants using the CTCC or i-Tree Streets can use the i-Tree Streets species by climate zone list to assist in selecting the most appropriate proxy from the available species.

Age (CTCC) or DBH (i-Tree Streets) of trees 40 years after project start	
CTCC The CTCC uses tree age to provide an estimate of total carbon stored. The age to be input is the age of the tree 40 years from the start of the project so applicants must estimate the age of the trees at the time of planting and expected year of planting. For example, if a project that starts in 2017 plants a 1 year old tree in 2019, the age input will be 38 years (age of tree in 2046).	**i-Tree Streets** i-Tree Streets uses DBH to provide an estimate of the total carbon stored.[5] i-Tree Streets allows input of either an exact DBH or a range. If entering an exact number, the applicant will enter the DBH expected 40 years after project start. If entering a DBH class, the applicant will enter a number 1-9 that corresponds with the default range expected at that time.
Climate zone where tree planting will occur	
Use the map in Figure 2 below to identify which of the climate zones (referred to as climate regions in i-Tree Streets) the project will be located in. Climate zone boundaries are approximate; if in doubt, match cooling degree days and heating degree days for the project location with those in Table 6. Applicants can find information on local cooling degree days and heating degree days from the Western Regional Climate Center at: http://www.wrcc.dri.edu/summary/lcdus08.html	

If tree planting sites are strategically selected to shade buildings (i.e., planted within 60 feet), applicants can also account for GHG emission reductions from building energy savings by entering additional information. Table 5 describes the information needed to estimate GHG emission reductions from energy savings.

Table 5. Required Information for Estimating GHG Emission Reductions from Building Energy Savings

Tree Location and Building Energy Use	
CTCC To calculate building energy savings, the CTCC requires inputs for tree azimuth (compass bearing), distance from the nearest air-conditioned/heated building, building vintage, and type of air conditioning and heating equipment of nearest building. Because it is unlikely that specific tree site locations will be identified at the time of application submission, applicants can extrapolate information from previous planting efforts and neighborhood characteristics.	**i-Tree Streets** To calculate building energy savings, i-Tree Streets relies on tree species and size and embedded default values based on project location as described in the i-Tree Streets Reference City Community Tree Guides available at: https://www.itreetools.org/resources/archives.php. No additional inputs are required by applicants.

[5] Applicants that need assistance estimating tree DBH can utilize the CTCC tool for this purpose. After entering the climate zone, species, and age of the tree, the CTCC will populate a DBH estimate that applicants may use in i-Tree.

Figure 2. California Climate Zones

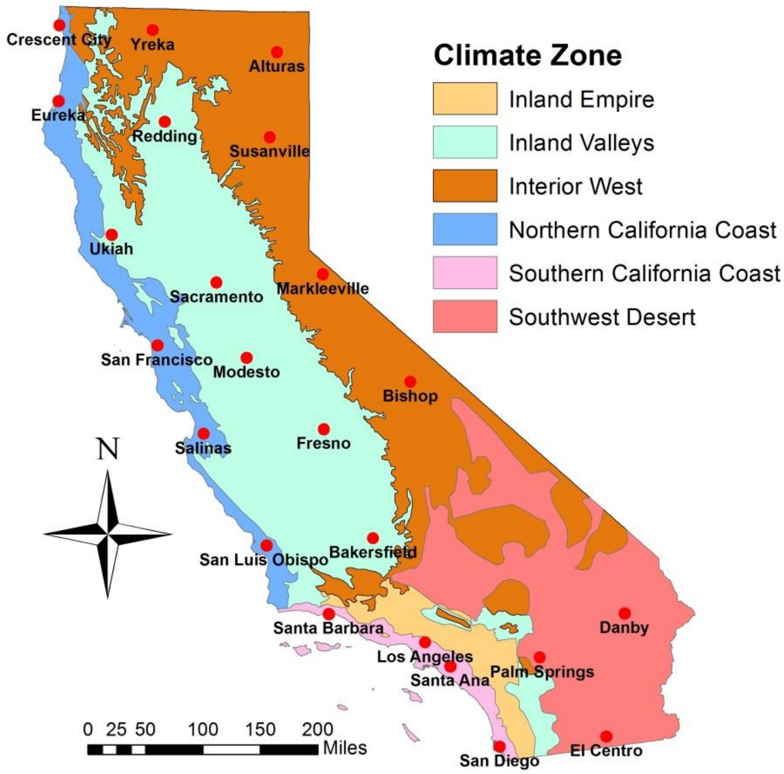


Table 6. Climate Zones

Climate Region	Reference City	CDD1	HDD2
Interior West	Albuquerque, NM	1210	4362
Northern California Coast	Berkeley, CA	69	3237
Temperate Interior West	Boise, ID	692	6001
Coastal Plain	Charleston, SC	2011	2209
South	Charlotte, NC	1514	3415
Inland Empire	Claremont, CA	937	2133
North	Fort Collins, CO	623	6013
Desert Southwest	Glendale, AZ	3815	1153
Tropical	Honolulu, HI	4327	0
Lower Midwest	Indianapolis, IN	911	5690
Midwest	Minneapolis, MN	634	8002
Inland Valleys	Modesto, CA	1884	2602
Northeast	Queens, NY	1002	5088
Southern California Coast	Santa Monica, CA	470	1291
Central Florida	Orlando, FL	3400	631
Pacific Northwest	Longview, WA	279	4461

[1]CDD=Cooling Degree Days

[2]HDD=Heating Degree Days

B. Aboveground Biomass of Removed Trees to be Utilized

Table 7 describes the information needed to estimate the aboveground biomass of removed trees to be utilized by the project using the CTCC. Applicants with an urban wood and biomass utilization component may estimate the GHG benefits for a 10 year period; only trees that are expected to be utilized during that time should be entered into the CTCC and UCF GHG Calculator Tool.

Table 7. Required Information for Estimating Aboveground Biomass of Removed Trees to be Utilized

Trees species to be utilized
The CTCC includes a list of species to choose from found in Appendix B of this quantification methodology. Applicants will need to enter a 2 to 6 character code consisting of the first two letters of the genus name and the first two letters of the species name followed by two optional numbers to distinguish two species with the same four-letter code (USDA National Plants Database). **User Tip:** The use of proxy species (the species that best matches the genus, size, and other characteristics of a tree to be planted) may be necessary if the species to be planted by the project are not available options within the CTCC. Applicants using the CTCC can use the i-Tree Streets species by climate zone list to assist in selecting the most appropriate proxy species of the available species.
Age or DBH of trees at time of removal
The CTCC uses tree age or DBH to provide an estimate of aboveground biomass. Applicants may choose which metric to use.
Climate zone where tree planting will occur
Use the map in Figure 2 above to identify which of the climate zones the project will be located in. Climate zone boundaries are approximate; if in doubt, match cooling degree days and heating degree days for the project location with those in Table 6. Applicants can find information on local cooling degree days and heating degree days from the Western Regional Climate Center at: http://www.wrcc.dri.edu/summary/lcdus08.html.

Step 4. Enter Project-Specific Values into the CTCC and/or i-Tree Streets

The following subsections provide instruction on using the project-specific values determined in Step 3 and emission factors provided to estimate the carbon stored in trees (CTCC or i-Tree Streets), GHG emission reductions from building energy savings (CTCC or i-Tree Streets), and aboveground biomass of trees to be utilized (CTCC only). Applicants can choose which of these tools to use to estimate the GHG benefit of tree planting, but only the CTCC provides an estimate of tree biomass so applicants must use this tool to estimate the GHG benefit of biomass utilization. The subsections below provide quantification methods for both tools, where applicable. Applicants must follow the instructions applicable to the urban tree carbon accounting tool selected.

A. Tree Carbon Storage and GHG Emission Reductions from the Effects of Tree Shade on Building Energy Use

CTCC

After downloading the CTCC, open the “CarbonCalculator31” workbook and go to the “CTCC” worksheet. For each tree and planting tree site modeled, enter values into the grey input cells as indicated in Table 8.

Some tree planting sites may not provide shade to buildings and will therefore not result in building energy savings. When modeling these trees, applicants only need to enter information into the five input fields listed under “All tree planting sites” and should delete any values in other grey cells.

> **User Tip:**
> The CTCC calculates tree carbon storage and emission reductions from building energy savings on a per tree basis.
>
> Applicants do not need to model every tree to be planted but should run enough scenarios of likely combinations of tree and tree planting site characteristics in order to obtain sufficient data to accurately represent the proposed project.
>
> Proposed projects with more variety in tree and planting site characteristics will require more individual runs in the CTCC than those with more uniform tree and planting site characteristics.

Table 8. Required Inputs for Estimating Carbon Storage and Energy Savings

All tree planting sites	
Flag1	Enter 0 to compute values based on age
Flag2	Enter 0 to compute values based on shade effects only
Climate Zone	Select the project-specific California climate zone determined in Step 3
Species code and scientific name	Select the tree species (or proxy species) to be planted for the project as determined in Step 3
Age (years)	Enter the tree age 40 years after project start as determined in Step 3
Tree planting sites that are strategically selected to shade buildings (i.e., planted within 60 feet)	
Electricity CO_2 emission factor	Enter 303 kg CO_2e/MWh[6]
Electricity CH_4 emission factor	Enter 0 kg CH_4/MWh[7]
Electricity N_2O emission factor	Enter 0 kg N_2O/MWh[7]
Tree azimuth	Enter the compass bearing of the tree from the nearest building (i.e., N, NE, E, SE, S, SW, W, or NW) as determined in Step 3
Tree distance class	Select the distance from tree to nearest air-conditioned/ heated space (i.e., <20 ft, 20-40 ft, 40-60 ft, or >60 ft) as determined in Step 3
Building vintage	Enter the vintage of the nearest building (i.e., pre-1950, 1950-80, or post-1980) as determined in Step 3
Air conditioning equipment	Enter 1 for central air/heat, 2 for evaporative cooler, 3 for wall/window unit, 0 for none as determined in Step 3
Heating equipment	Enter 1 for natural gas, 2 for heat pump, 3 for electric resistance, 4 for oil or other fossil fuel, or 0 for none as determined in Step 3
Heating CO_2 emission factor	53.1 kg CO_2e/MBtu[8]
Heating CH_4 emission factor	Enter 0 kg/MBtu[9]
Heating N_2O emission factor	Enter 0 kg/MBtu[9]

[6] For the purposes of GGRF quantification methodologies, ARB developed a California grid electricity emission factor based on 2013 data for total in-state and imported electricity emissions (89,840,000 MT CO2e) divided by total consumption (296,203,000 MWh). Emissions data for 2013 were obtained from the ARB GHG inventory, dated March 30, 2016, available online at: https://www.arb.ca.gov/cc/inventory/data/data.htm.
Consumption data for 2013 were obtained from the CEC Energy Almanac, as of September 10, 2015, available online at: http://energyalmanac.ca.gov/electricity/electricity_generation.html.

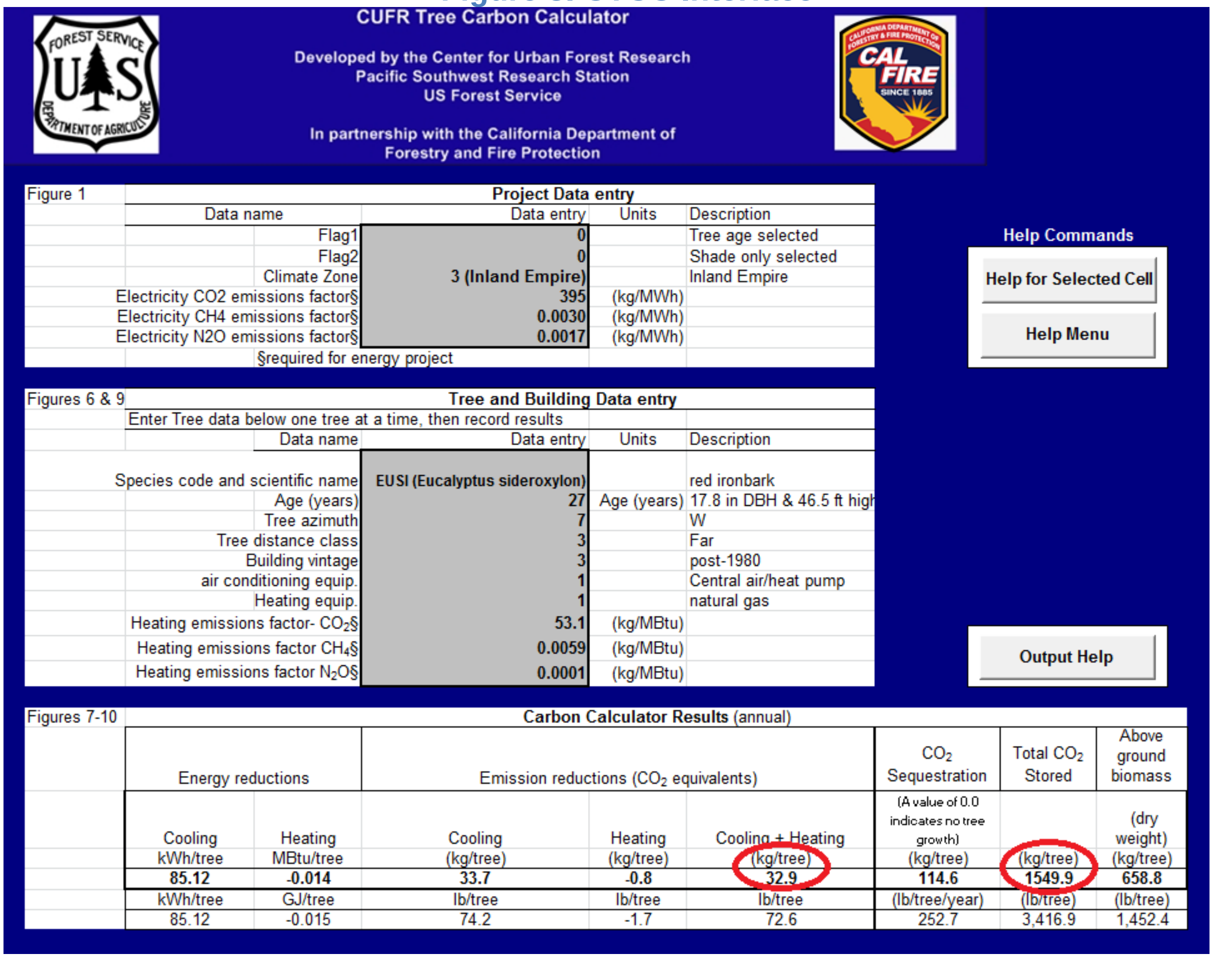
[7] Emissions of methane (CH_4) and nitrous oxide (N_2O) are captured in the 303 kg CO_2e/MWh used for the Electricity CO_2 emission factor.

[8] EPA Emission Factors for Greenhouse Gas Inventories (2014, April 4), available online at: http://www.epa.gov/climateleadership/documents/emission-factors.pdf

[9] Emissions of methane (CH_4) and nitrous oxide (N_2O) are captured in the 53.1 kg CO_2e/MBtu used for the Heating CO_2 emission factor.

The CTCC provides carbon stored and emission reductions from energy savings outputs for each tree. The CTCC does not aggregate the individual tree outputs. The applicant will enter the data in the output fields, shown circled in red in Figure 3, from each run into the UCF GHG Calculator Tool in order to calculate the total carbon stored and total emission reductions from energy savings for the project.

Figure 3. CTCC Interface



> **User Tip:**
> Applicants must keep the carbon storage output values and the GHG emission reductions from building energy savings output values independent from one another as these values will need to be input separately into the UCF GHG Calculator Tool and reported separately in the application.

i-Tree Streets

Applicants have the option of entering tree and tree planting site information directly into i-Tree Streets or uploading information from a Microsoft Access database that meets the i-Tree Streets formatting requirements. Database formatting requirements can be found in the i-Tree Streets User's Manual available at: https://www.itreetools.org/resources/manuals/Streets_Manual_v5.pdf or a supplementary guidebook, Formatting Existing Inventories into Streets, available at: https://www.itreetools.org/streets/resources/Formatting_Existing_Inventories_for_Streets.pdf.

After downloading the i-Tree software suite, open i-Tree Streets and create a new project by clicking on the File menu > Open > New Project; a pop-up window will appear. Enter the information as indicated in Table 9.

Table 9. Required Inputs for Creating a New i-Tree Streets Project

New Project Inputs	
Database	Select create new to enter inventory information or select existing to upload inventory information.
Project Name	Enter the name of the project
Inventory Type	Select complete[10]
Year	Enter the year 40 years after project start
Climate Region	Select the project-specific California climate zone determined in Step 3

After entering this information, click "Finish". A series of pop-up windows will appear titled "Define City," "Define Cost," and "Benefit Prices." No entry is required in these windows and applicants may click "Cancel" in each window.[11] A pop-up window titled "User Defined Fields" will appear. Under the DBH tab, applicants can select to use the range (class) or exact DBH (measurement) and choose to enter DBH in inches or centimeters. Applicants can review the data descriptions in the other tabs and customize fields as desired. When finished, click "OK."

Applicants that choose to enter tree data directly into i-Tree Streets will start the process by clicking Input > Records. Click "New" in the pop-up window to enter a new tree record. Enter the information as indicated in Table 10 for each tree to be planted by the project.[11] Applicants that choose to upload tree and tree planting site data from a formatted database will start the process by compiling the data indicated in Table 10 for each tree to be planted by the project. When formatted to be compatible with i-Tree Streets, save the database and return to i-Tree Streets. Click File > Import > Inventory Data and follow the prompts to upload the data into i-Tree Streets.

[10] i-Tree Streets allows users to use a sample or complete inventory. For the purpose of this quantification methodology, applicants must provide a complete inventory (i.e., create a tree record for every tree to be planted by the project).

[11] Applicants may choose to input additional information but it is not required and will not impact the outputs used in this quantification methodology and the UCF GHG Calculator Tool.

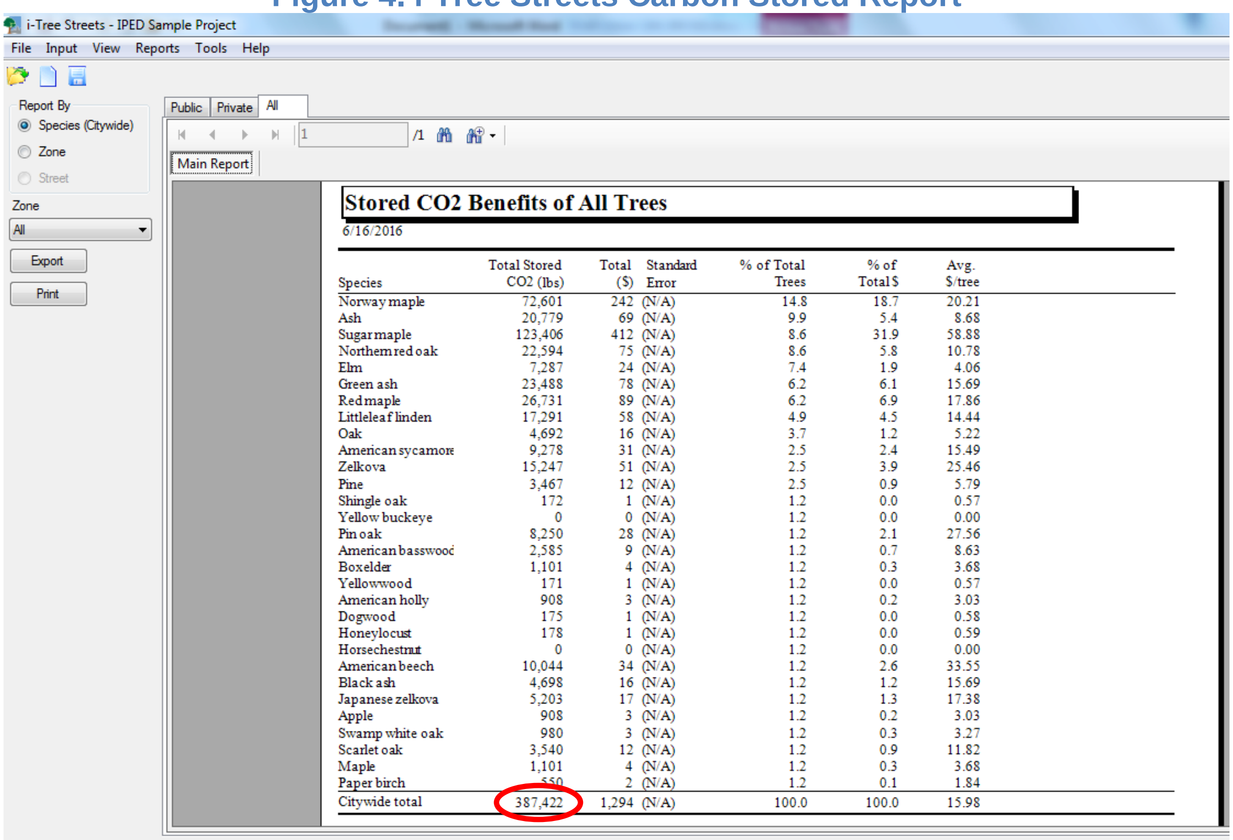
Table 10. Required Inputs for Estimating Carbon Storage and Energy Savings

Tree and Tree Planting Site Inputs	
Species (Tree Info tab)	Select the tree species (or proxy species) to be planted for the project as determined in Step 3
DBH (Tree Info tab)	If using ranges, select the DBH size class of the tree 40 years after project start as determined in Step 3. If using exact values, enter the DBH of the tree 40 years after project start as determined in Step 3.

After a complete tree inventory is entered or uploaded, applicants must run two reports in i-Tree Streets to obtain the project values for carbon storage and building energy savings.

To obtain the value for carbon storage, click Reports > Benefit-Cost Analysis > Annual Benefits > Carbon Stored. A report will appear that lists the stored carbon (lb CO_2e) for each species included in the inventory. The total carbon stored for the population of trees to be planted by the project is at the bottom of the report. The applicant will enter the total carbon value, shown circled in red in Figure 4, into the UCF GHG Calculator Tool in order to calculate the total carbon stored for the project.

Figure 4. i-Tree Streets Carbon Stored Report



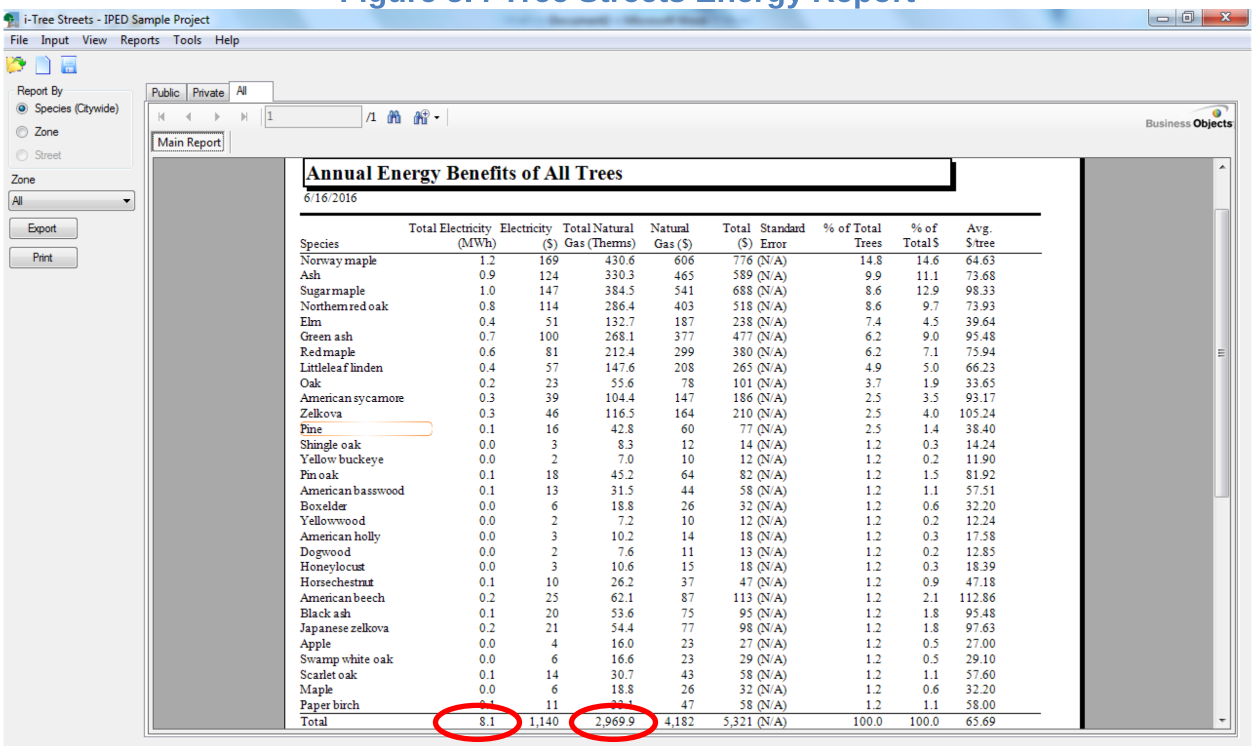
Stored CO2 Benefits of All Trees

6/16/2016

Species	Total Stored CO2 (lbs)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	72,601	242	(N/A)	14.8	18.7	20.21
Ash	20,779	69	(N/A)	9.9	5.4	8.68
Sugar maple	123,406	412	(N/A)	8.6	31.9	58.88
Northern red oak	22,594	75	(N/A)	8.6	5.8	10.78
Elm	7,287	24	(N/A)	7.4	1.9	4.06
Green ash	23,488	78	(N/A)	6.2	6.1	15.69
Red maple	26,731	89	(N/A)	6.2	6.9	17.86
Littleleaf linden	17,291	58	(N/A)	4.9	4.5	14.44
Oak	4,692	16	(N/A)	3.7	1.2	5.22
American sycamore	9,278	31	(N/A)	2.5	2.4	15.49
Zelkova	15,247	51	(N/A)	2.5	3.9	25.46
Pine	3,467	12	(N/A)	2.5	0.9	5.79
Shingle oak	172	1	(N/A)	1.2	0.0	0.57
Yellow buckeye	0	0	(N/A)	1.2	0.0	0.00
Pin oak	8,250	28	(N/A)	1.2	2.1	27.56
American basswood	2,585	9	(N/A)	1.2	0.7	8.63
Boxelder	1,101	4	(N/A)	1.2	0.3	3.68
Yellowwood	171	1	(N/A)	1.2	0.0	0.57
American holly	908	3	(N/A)	1.2	0.2	3.03
Dogwood	175	1	(N/A)	1.2	0.0	0.58
Honeylocust	178	1	(N/A)	1.2	0.0	0.59
Horsechestnut	0	0	(N/A)	1.2	0.0	0.00
American beech	10,044	34	(N/A)	1.2	2.6	33.55
Black ash	4,698	16	(N/A)	1.2	1.2	15.69
Japanese zelkova	5,203	17	(N/A)	1.2	1.3	17.38
Apple	908	3	(N/A)	1.2	0.2	3.03
Swamp white oak	980	3	(N/A)	1.2	0.3	3.27
Scarlet oak	3,540	12	(N/A)	1.2	0.9	11.82
Maple	1,101	4	(N/A)	1.2	0.3	3.68
Paper birch	550	2	(N/A)	1.2	0.1	1.84
Citywide total	387,422	1,294	(N/A)	100.0	100.0	15.98

To obtain the value for building energy savings, click Reports > Benefit-Cost Analysis > Annual Benefits > Energy. A report will appear that lists the electricity (MWh) and natural gas savings (therms) for each species included in the inventory. The total electricity and natural gas savings for the population of trees to be planted by the project are at the bottom of the report. The applicant will enter the total electricity and total natural gas savings, shown circled in red in Figure 5, into the UCF GHG Calculator Tool in order to calculate the GHG benefit from building energy savings for the project.

Figure 5. i-Tree Streets Energy Report



Annual Energy Benefits of All Trees

6/16/2016

Species	Total Electricity (MWh)	Electricity ($)	Total Natural Gas (Therms)	Natural Gas ($)	Total ($)	Standard Error	% of Total Trees	% of Total $	Avg. $/tree
Norway maple	1.2	169	430.6	606	776	(N/A)	14.8	14.6	64.63
Ash	0.9	124	330.3	465	589	(N/A)	9.9	11.1	73.68
Sugar maple	1.0	147	384.5	541	688	(N/A)	8.6	12.9	98.33
Northern red oak	0.8	114	286.4	403	518	(N/A)	8.6	9.7	73.93
Elm	0.4	51	132.7	187	238	(N/A)	7.4	4.5	39.64
Green ash	0.7	100	268.1	377	477	(N/A)	6.2	9.0	95.48
Red maple	0.6	81	212.4	299	380	(N/A)	6.2	7.1	75.94
Littleleaf linden	0.4	57	147.6	208	265	(N/A)	4.9	5.0	66.23
Oak	0.2	23	55.6	78	101	(N/A)	3.7	1.9	33.65
American sycamore	0.3	39	104.4	147	186	(N/A)	2.5	3.5	93.17
Zelkova	0.3	46	116.5	164	210	(N/A)	2.5	4.0	105.24
Pine	0.1	16	42.8	60	77	(N/A)	2.5	1.4	38.40
Shingle oak	0.0	3	8.3	12	14	(N/A)	1.2	0.3	14.24
Yellow buckeye	0.0	2	7.0	10	12	(N/A)	1.2	0.2	11.90
Pin oak	0.1	18	45.2	64	82	(N/A)	1.2	1.5	81.92
American basswood	0.1	13	31.5	44	58	(N/A)	1.2	1.1	57.51
Boxelder	0.0	6	18.8	26	32	(N/A)	1.2	0.6	32.20
Yellowwood	0.0	2	7.2	10	12	(N/A)	1.2	0.2	12.24
American holly	0.0	3	10.2	14	18	(N/A)	1.2	0.3	17.58
Dogwood	0.0	2	7.6	11	13	(N/A)	1.2	0.2	12.85
Honeylocust	0.0	3	10.6	15	18	(N/A)	1.2	0.3	18.39
Horsechestnut	0.1	10	26.2	37	47	(N/A)	1.2	0.9	47.18
American beech	0.2	25	62.1	87	113	(N/A)	1.2	2.1	112.86
Black ash	0.1	20	53.6	75	95	(N/A)	1.2	1.8	95.48
Japanese zelkova	0.2	21	54.4	77	98	(N/A)	1.2	1.8	97.63
Apple	0.0	4	16.0	23	27	(N/A)	1.2	0.5	27.00
Swamp white oak	0.0	6	16.6	23	29	(N/A)	1.2	0.5	29.10
Scarlet oak	0.1	14	30.7	43	58	(N/A)	1.2	1.1	57.60
Maple	0.0	6	18.8	26	32	(N/A)	1.2	0.6	32.20
Paper birch	[illegible]	11	[illegible]	47	58	(N/A)	1.2	1.1	58.00
Total	8.1	1,140	2,969.9	4,182	5,321	(N/A)	100.0	100.0	65.69

B. Aboveground Biomass of Removed Trees to be Utilized

The net GHG benefit of biomass utilization is based on the aboveground biomass of removed trees to be utilized over a 10 year period. Applicants must use the CTCC to estimate the aboveground biomass of urban trees to be utilized because i-Tree Streets does not provide such an estimate. This subsection provides instructions for the CTCC.

After downloading the CTCC, open the “CarbonCalculator31” workbook and go to the “CTCC” worksheet. For each tree modeled, enter values into the grey input cells as indicated in Table 11. Delete any values in other grey cells.

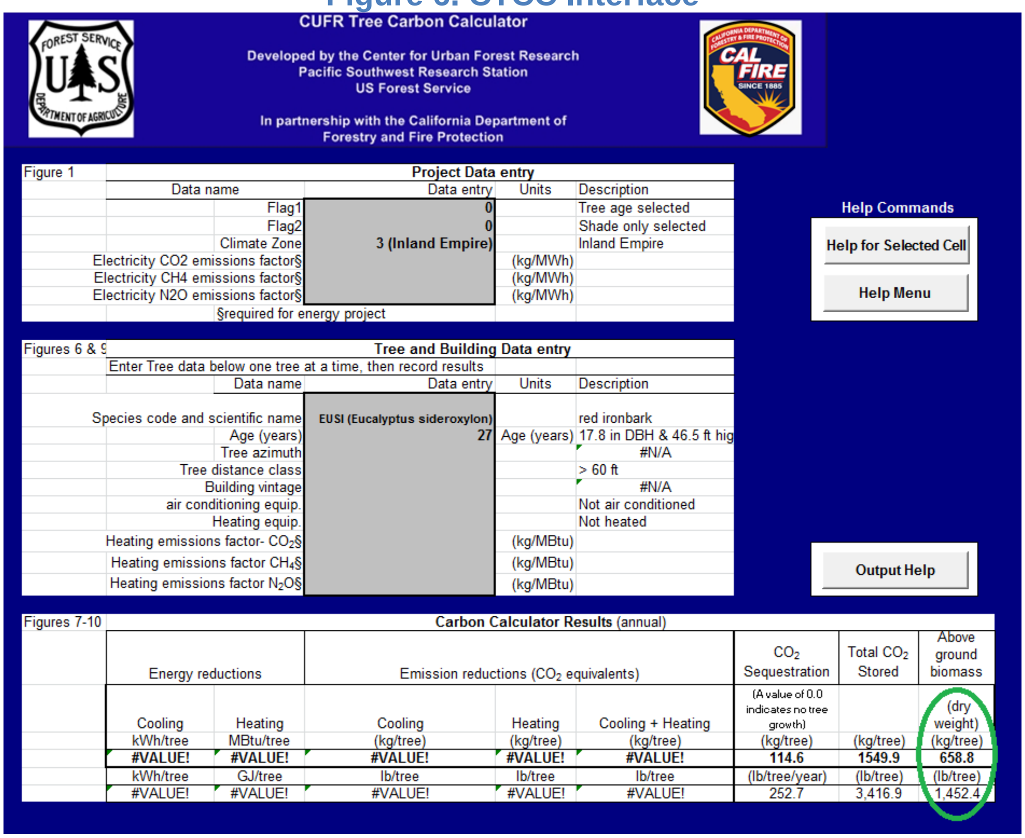
> **User Tip:**
> The CTCC calculates tree aboveground biomass on a per tree basis.
>
> Applicants do not need to model every tree to be utilized but should run enough scenarios of tree characteristics in order to obtain sufficient data to accurately represent the trees likely to be utilized by the proposed project.
>
> Proposed projects with more variety in trees to be utilized will require more individual runs in the CTCC than those with more uniform tree characteristics.

Table 11. Required Inputs for Estimating Aboveground Biomass of Removed Trees to be Utilized

Tree Inputs	
Flag1	Enter 0 to compute values based on age, or 1 for DBH
Flag2	Enter 0 to compute values based on shade effects[12]
Climate Zone	Select the project-specific California climate zone as determined in Step 3
Species code and scientific name	Select the tree species (or proxy species) to be utilized by the project as determined in Step 3
Age (years)	Enter the tree age or DBH when the tree will be removed as determined in Step 3

The CTCC provides an aboveground biomass output for each tree. The CTCC does not aggregate the individual tree outputs. The applicant will enter the data in the output field, shown circled in green in Figure 6, from each run into the UCF GHG Calculator Tool in order to calculate the total aboveground biomass of removed trees to be utilized by the project. Projects utilizing biomass for wood products will input dry weight data using the kg/tree unit and projects utilizing biomass for electricity generation will use the lb/tree unit in the UCF GHG Calculator Tool.

Figure 6. CTCC Interface



[12] Energy reductions from tree shade are not used in the computation of aboveground biomass.

Step 5: Estimate the Net GHG Benefit for the Proposed Project Using the UCF GHG Calculator Tool

Applicants must use the UCF GHG Calculator Tool to complete this step. The Calculator Tool can be downloaded from https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/quantification.htm.

Users should begin with the **Read Me** tab, which contains instructions and prompts users to enter project information. Key terms are defined in the **Definitions** tab. The **calculation** tabs identify inputs required by the user, generally requiring project-specific data or assumptions. Input and output fields are color coded:

- Yellow fields indicate a direct user input is required.
- Green fields indicate a selection from a drop-down box is required.
- Gray fields indicate output or calculation fields that are automatically populated based on user entries and the calculation methods.

Details of calculation methods are provided in Appendix B.

The **GHG Summary** tab displays the total project GHG benefit as well as the estimated total project GHG benefit per UCF GGRF dollar and per total GGRF dollar requested, as described below.

- **Total Project GHG Benefit** is equal to the sum total of each of the GHG Benefits calculated in Section B and are automatically summed in the UCF GHG Calculator Tool in the **GHG Summary** tab.

- **Total Project GHG Benefit per Dollar of UCF GGRF Funds Requested** is calculated as:

$$\frac{\mathit{Total\ Project\ GHG\ Benefit\ in\ Metric\ Tons\ of\ CO_2e}}{\mathit{UCF\ GGRF\ Funds\ Requested}\ (\$)}$$

  Applicants should enter the UCF GGRF Funds Requested ($) for all project features into the UCF GHG Calculator Tool. This amount is equal to the amount of GGRF dollars the applicant is requesting from CAL FIRE's UCF program. The UCF GHG Calculator Tool will provide the Total Project GHG Benefit per UCF GGRF Funds Requested.

- **Total Project GHG Benefit per Dollar of GGRF** requested is calculated as:

$$\frac{\mathit{Total\ Project\ GHG\ Benefit\ in\ Metric\ Tons\ of\ CO_2e}}{\mathit{Total\ GGRF\ Funds\ Requested}\ (\$)}$$

  Applicants should enter the Total GGRF Funds Requested ($) into the UCF GHG Calculator Tool for all project features. This amount is equal to the amount of GGRF dollars the applicant is requesting from CAL FIRE's UCF program, plus all GGRF dollars from CAL FIRE or other agencies that have previously been awarded to the same project and any GGRF dollars from agencies other than

CAL FIRE that the project has or plans to apply for. For a list of GGRF funded programs, go to: https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/ggrfprogrampage.htm. If no other GGRF funds are requested, this will be the same amount as the UCF GGRF Funds Requested. The UCF GHG Calculator Tool will provide the Total Project GHG Benefit per GGRF Funds Requested.

Section C. Documentation

In addition to UCF application requirements, applicants for GGRF funding are required to document results from the use of this quantification methodology, including supporting materials to verify the accuracy of project-specific inputs.

Applicants are required to provide electronic documentation that is complete and sufficient to allow the calculations to be reviewed and replicated. Paper copies of supporting materials must be available upon request by agency staff.

The following checklist is provided as a guide to applicants; additional data and/or information may be necessary to support project-specific input assumptions.

	Documentation Description	**Completed**
1.	Project description, including excerpts or specific references to the location in the main UCF application of the project information necessary to complete the applicable portions of the quantification methodology	
2.	Populated UCF GHG Calculator Tool file (in .xlsx) with worksheets applicable to the project populated (ensure that the net GHG benefit and net GHG benefit/GGRF $ requested fields in the summary worksheet contain calculated values)	
3.	If the Total GGRF Funds Requested are different than the UCF GGRF Funds Requested, identify the other GGRF program(s) where funding is sought, including the fiscal year of the application(s)	
4.	Electronic copies of a spreadsheet showing the CTCC inputs and outputs for each tree and tree planting site scenario modeled	
5.	Electronic copies of the tree population inventory used in i-Tree Streets	
6.	Electronic copy of i-Tree Carbon Stored and Energy reports	
7.	Any other information as necessary and appropriate to substantiate inputs (e.g., DBH, tree planting site characteristics, etc.)	

Section D. Reporting after Funding Award

Accountability and transparency are essential elements for all GGRF California Climate Investment projects. As described in ARB's Funding Guidelines for Agencies that Administer California Climate Investments (Funding Guidelines),[13] each administering agency is required to track and report on the benefits of the California Climate Investments funded under their program(s). Each project funded by the GGRF is expected to provide a real and quantifiable net GHG benefit. The previous sections of this document provide the methods and tools to estimate the net GHG benefit of a proposed project based on project characteristics and assumptions of expected conditions and activity levels. This section explains the minimum reporting requirements for administering agencies and funding recipients during project implementation, termed Phase 1, and after a project is completed, termed Phase 2. Table 12 below shows the project phases and when reporting is required.

Table 12. Quantification and Reporting By Project Phase

	Timeframe & Reporting Frequency	Quantification Methods
Project Selection	Period from solicitation to selection of projects and funding awards. Applicant submits application to CAL FIRE by due date in solicitation materials.	All applicants use methods in ARB's quantification methodology to estimate the net GHG benefit of the project.
Phase 1	Period from project award date through project completion date. CAL FIRE reports to ARB on an annual basis.	All awarded projects use methods in ARB's quantification methodology to update initial estimate of net GHG benefit, as needed, based on project changes.
Phase 2	Begins after project completion. CAL FIRE reports to ARB consistent with the Funding Guidelines.	GHG reduction estimates are updated and reported for a subset of awarded projects.

Funding recipients have the obligation to provide, or provide access to, data and information on project outcomes to CAL FIRE. Applicants should familiarize themselves with the requirements below as well as those within the UCF solicitation materials (e.g., guidelines, applications, etc.), and grant agreement.

It is the responsibility of administering agencies to collect and compile project data from funding recipients, including the net GHG benefit and information on benefits to disadvantaged communities.

Phase 1 reporting is required for all UCF projects. CAL FIRE will collect and submit data to ARB to satisfy Phase 1 reporting requirements. Projects must report any

[13] California Air Resources Board. Funding Guidelines for Agencies Administering California Climate Investments. (December 21, 2015). https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/arb-fundingguidelines-for-ca-climate-investments.pdf

changes that impact the net GHG benefit estimate (i.e., assumptions or quantities) to CAL FIRE prior to project completion.

Phase 2 reporting is required for only a subset of UCF projects and is intended to document actual project benefits achieved after the project is completed. Phase 2 data collection and reporting will not be required for every project. CAL FIRE will be responsible for identifying the subset of individual projects that must complete Phase 2 reporting, identifying who will be responsible for collecting Phase 2 data, and for reporting the required information to ARB. ARB will work with CAL FIRE to address Phase 2 procedures, including but not limited to:

- The **timelines** for Phase 2 reporting, i.e., when does Phase 2 reporting begin, how long will Phase 2 reporting be needed.
- As applicable, **approaches for determining the subset of projects** that need Phase 2 reporting (i.e., how many **X** projects out of **Y** total projects are required to have Phase 2 reporting).
- **Methods for monitoring or measuring** the necessary data to quantify and document achieved GHG reductions and other select project benefits.
- **Data to be collected**, including data fields needed to support quantification of GHG emission benefits.
- Reporting requirements for transmitting the data to ARB or CAL FIRE for program transparency and use in reports.

Once the Phase 2 quantification method and data needs are determined, ARB will develop and post the final ARB approved Phase 2 methodology for use in Phase 2 reporting.

Section E. References

The following references were used in the development of this quantification methodology and the accompanying UCF GHG Calculator Tool.

California Air Resources Board. (March 2016). Draft Method for Estimating Greenhouse Gas Emission Reductions from Diversion of Organic Waste from Landfills to Compost Facilities. https://www.arb.ca.gov/cc/waste/waste.htm

California Air Resources Board. (March 30, 2016). *California Greenhouse Gas Emissions Inventory*. http://www.arb.ca.gov/cc/inventory/data/data/htm.

California Energy Commission. (September 10, 2015). *Energy Almanac*. http://energyalmanac.ca.gov/electricity/electricity_generation.html.

California Air Resources Board. (June 25, 2015). Compliance Offset Protocol U.S. Forest Projects. https://www.arb.ca.gov/cc/capandtrade/protocols/usforest/forestprotocol2015.pdf

California Air Resources Board & California Department of Resources, Recycling, and Recovery. (September 17, 2013). *Biomass Conversion.* https://www.arb.ca.gov/cc/waste/biomassconversion.pdf

California Air Resources Board. (February 27, 2009). *Detailed California-Modified GREET Pathway for Cellulosic Ethanol from Forest Waste*. https://www.arb.ca.gov/fuels/lcfs/022709lcfs_forestw.pdf

Center for Urban Forest Research. *CUFR Tree Carbon Calculator – Help Menu*. http://www.fs.usda.gov/ccrc/sites/default/files/Carbon_Calculator.zip

Roman, Lara. (Spring 2014). How many trees are enough? Tree death and the urban canopy. *Scenario Journal*. http://www.fs.fed.us/nrs/pubs/jrnl/2014/nrs_2014_roman_001.pdf

Sonoma County Water Agency. (2013). *Feasibility of Using Residual Woody Biomass to Generate Electricity for Sonoma County*. http://www.scwa.ca.gov/files/docs/carbon-free-water/SCWA Bioenergy Feasibility Assessment_WDFeatherman_FINAL REPORT_2014-05-17.pdf

United States Department of Agriculture, Forest Service. *i-Tree Streets User's Manual v.5.0*. https://www.itreetools.org/resources/manuals/Streets_Manual_v5.pdf

United States Department of Agriculture Forest Service. *i-Tree ECO Guide to Using the Forecast Model*. http://www.itreetools.org/resources/manuals/Ecov6_ManualsGuides/Ecov6Guide_UsingForecast.pdf

United States Department of Agriculture, Forest Service. *i-Tree Streets Reference City Community Tree Guides* (multiple publications). https://www.itreetools.org/resources/archives.php

United States Department of Energy Information Administration. (April 1998). *Method for Calculating Carbon Sequestration by Trees in Urban and Suburban Settings*. http://www3.epa.gov/climatechange/Downloads/method-calculating-carbon-sequestration-trees-urban-and-suburban-settings.pdf

United States Environmental Protection Agency (April 4, 2014) *Emission Factors for Greenhouse Gas Inventories*. https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf

Western Regional Climate Center. *LCD Summaries for the Western U.S*. http://www.wrcc.dri.edu/summary/lcdus08.html

Appendix A. Equations Supporting the UCF GHG Calculator Tool

Methods used in the UCF GHG Calculator Tool for estimating the net GHG benefit by activity type are provided in this appendix. The net GHG benefit from the project is quantified within the UCF GHG Calculator Tool using the equations below.

Note: Due to the difference in the outputs from the two urban tree accounting tools available for use, some equations are tool specific as indicated below. Applicants will need to use the appropriate worksheets in the GHG Calculator Tool depending on whether they are inputting carbon and building energy savings estimates derived from the CTCC or i-Tree.

A. GHG Benefit of Carbon Stored in Trees Planted by the Project

The GHG benefit from carbon stored in trees planted by the project is calculated as the sum of carbon stored in individual trees 40 years after project start, accounting for a 3% annual tree mortality rate for the years after the period of establishment care (including replacement) provided by the project through year 10.[14] Equation 1 is used to determine the GHG benefit from carbon stored in live project trees at the end of the project if the applicant used the CTCC. Equation 2 is used if the applicant used i-Tree Streets.

Equation 1: GHG Benefit of Carbon Stored in Live Project Trees *(CTCC)*

$$GHG_{CSC} = \frac{\sum_i (C_{CTCC,\,i} \times Q_i) \times (1 - 0.03)^{10-YC}}{1000}$$

Where,			Units
GHG_{CSC}	=	GHG benefit of carbon stored in live project trees estimated using the CTCC	MT CO_2e
$C_{CTCC,i}$	=	Carbon stored in project tree i 40 years after project start (from the CTCC)	kg CO_2e
Q_i	=	Quantity of trees planted with the characteristics of tree i	trees
0.03	=	Mortality rate (3% annual)	%
10	=	Years after planting with greatest risk for mortality	years
YC	=	Years of establishment and replacement care provided by project (the maximum value for the purposes of this equation is 9 years; enter 9 if the project provides establishment and replacement care for a longer period of time)	years
i	=	Project tree planted	
1000	=	Conversion factor from kg to MT	kg/MT

Equation 2: GHG Benefit of Carbon Stored in Live Project Trees *(i-Tree Streets)*

$$GHG_{CSI} = \frac{C_{ITS} \times (1 - 0.03)^{10-YC}}{2202.62}$$

Where,			Units
GHG_{CSI}	=	GHG benefit of carbon stored in live project trees estimated using i-Tree Streets	MT CO_2e
C_{ITS}	=	Total carbon stored in population of project trees 40 years after project start (from the i-Tree Streets)	lb CO_2e
0.03	=	Mortality rate (3% annual)	%
10	=	Years after planting with greatest risk for mortality	years
YC	=	Years of establishment and replacement care provided by project (the maximum value for the purposes of this equation is 9 years; enter 9 if the project provides establishment and replacement care for a longer period of time)	years
2202.62	=	Conversion factor from lb to MT	lb/MT

[14] Establishment and replacement care reduces the risk of mortality of trees planted by the project. Because this methodology applies an annual mortality rate only to the first ten years after planting when trees are most at risk, the maximum value for years of establishment care in Equations 1-4 is 9 years.

B. GHG Benefit of Energy Savings as a Result of Strategically Planting Trees to Shade Buildings

The GHG benefit from emission reductions from energy savings is calculated as the total annual energy savings from individual trees planted strategically to shade buildings (i.e., planted within 60 feet) 40 years after project start, taking tree mortality into account, multiplied by 20 years. Because young trees do not provide significant shade and the energy savings value from i-Tree Streets is an estimate of the annual savings when the tree provides the greatest shade, the annual value is multiplied by 20 years to estimate the GHG emission benefit over 40 years.[15] Equation 3 is used to determine the GHG emission reductions from energy savings throughout the project if the applicant used the CTCC. Equation 4 is used if the applicant used i-Tree Streets.

Equation 3: GHG Benefit from Energy Savings *(CTCC)*

$$GHG_{ESC} = \frac{\sum_i (ER_{CTCC,\,i} \times Q_i) \times (1 - 0.03)^{10-YC}}{1000} \times 20$$

Where,			Units
GHG_{ESC}	=	GHG benefit from energy savings estimated using the CTCC	MT CO_2e
$ER_{CTCC,i}$	=	Annual emission reductions from energy savings from project tree i 40 years after project start (from the CTCC)	kg CO_2e
Q_i	=	Quantity of trees planted with the characteristics of tree i	trees
0.03	=	Mortality rate (3% annual)	%
10	=	Years after planting with greatest risk for mortality	years
YC	=	Years of establishment and replacement care provided by project (the maximum value for the purposes of this equation is 9 years; enter 9 if the project provides establishment and replacement care for a longer period of time)	years
i	=	Project tree planted	
1000	=	Conversion factor from kg to MT	kg/MT
20	=	Years adjusted for annual energy savings output at year 40	years

[15] Greg McPherson, Research Forester, US Forest Service (April 25, 2016) personal communication.

Equation 4: GHG Benefit from Energy Savings *(i-Tree Streets)*

$$GHG_{ESI} = \left(ER_{ITS} \times 0.306 + NG_{ITS} \times 0.005311\right) \times (1 - 0.03)^{10-YC} \times PTS \times 20$$

Where,			Units
GHG_{ESI}	=	GHG benefit from energy savings estimated using i-Tree Streets	MT CO_2e
ER_{ITS}	=	Total annual electricity reductions from population of project trees 40 years after project start (from the i-Tree Streets)	MWh
0.303	=	Emission factor for electricity	MT CO_2e/ MWh
NG_{ITS}	=	Total annual natural gas reductions from population of project trees 40 years after project start (from i-Tree Streets)	therms
0.005311	=	Emission factor for natural gas	MT CO_2e/ therm
0.03	=	Mortality rate (3% annual)	%
10	=	Years after planting with greatest risk for mortality	years
YC	=	Years of establishment and replacement care provided by project (the maximum value for the purposes of this equation is 9 years; enter 9 if the project provides establishment and replacement care for a longer period of time)	years
PTS	=	Percent of trees to be planted to shade buildings (i.e., within 60 feet)	%
20	=	Years adjusted for annual energy savings output at year 40	years

C. GHG Benefit of Carbon Stored Long-Term in Wood Products

The GHG benefit from carbon stored long-term in wood products is calculated based on the sum of the aboveground biomass utilized for wood products over a 10 year period, mill efficiency,[16] and the carbon storage factor of the wood products generated. Projects may use the actual efficiency from the mill where trees will be delivered, supported with documentation, or the appropriate default mill efficiency based on the type of wood provided in Table 13. If trees will be delivered to more than one mill with different efficiencies, applicants may provide a weighted mill efficiency. Equation 5 is used to determine the amount of carbon transferred to wood products.

Equation 5: Carbon Transferred to Wood Products

$$C_{WP} = \frac{\sum_i \left(AGB_{CTCC,\ WP,\ i} \times Q_{WP,\ i}\right) \times 0.5}{1000} \times ME$$

Where,			Units
C_{WP}	=	Carbon transferred to wood products	MT C
$AGB_{CTCC,WP,i}$	=	Aboveground biomass of project tree i at time of removal to be utilized for wood products (dry weight from the CTCC)	kg
$Q_{WP,i}$	=	Quantity of removed trees with the characteristics of tree i to be utilized for wood products	trees
i	=	Removed project tree to be utilized for wood products	
0.5	=	Conversion factor from wood to carbon	kg C/kg wood
1000	=	Conversion factor from kg to MT	kg/MT
ME	=	Mill efficiency	%

Table 13. Default Mill Efficiency

Hardwood	Softwood
56.8%	67.5%

After determining the carbon transferred to wood products, the amount of carbon stored long term in wood products must be calculated. To do this, determine the percentage of removed biomass that will go into each wood product class category. If not available from the mill that wood is delivered to, assume that 100% of the biomass goes into “miscellaneous products.” Default carbon storage factors, the percent of carbon transferred to wood products that remains stored long-term, are provided. Equation 6 is used to determine the GHG benefit of utilizing biomass for wood products.

[16] Mill efficiencies represent the portion of logs that are converted to wood products, or the percentage of the total carbon delivered to a mill that is transferred into wood products. For accounting purposes, the remainder of the carbon is considered to be immediately emitted to the atmosphere.

Equation 6: GHG Benefit of Carbon Stored in Wood Products

$$GHG_{WP} = [(C_{WP} \times SL \times 0.463) + (C_{WP} \times HL \times 0.250) + (C_{WP} \times SP \times 0.484) + (C_{WP} \times OS \times 0.582) + (C_{WP} \times NP \times 0.380) + (C_{WP} \times P \times 0.058) + (C_{WP} \times MP \times 0.176)] \times 3.67$$

Where,

			Units
GHG_{WP}	=	GHG benefit of carbon stored in wood products	MT CO_2e
C_{WP}	=	Carbon transferred to wood products (from Equation 5)	MT C
SL	=	Percentage of biomass that will go into softwood lumber	%
0.463	=	Carbon storage factor for softwood lumber	%
HL	=	Percentage of biomass that will go into hardwood lumber	%
0.250	=	Carbon storage factor for hardwood lumber	%
SP	=	Percentage of biomass that will go into softwood plywood	%
0.484	=	Carbon storage factor for softwood plywood	%
OS	=	Percentage of biomass that will go into oriented standboard	%
0.582	=	Carbon storage factor for oriented standboard	%
NP	=	Percentage of biomass that will go into nonstructural panels	%
0.380	=	Carbon storage factor for nonstructural panels	%
P	=	Percentage of biomass that will go into paper	%
0.058	=	Carbon storage factor for paper	%
MP	=	Percentage of biomass that will go into miscellaneous products	%
0.176	=	Carbon storage factor for miscellaneous products	%
3.67	=	Conversion factor from C to CO_2e	CO_2e/C

D. GHG Benefit of Utilizing Biomass for Electricity Generation

The GHG benefit from utilizing biomass for electricity generation is calculated as the sum of the aboveground biomass utilized for electricity generation via combustion and gasification over a 10 year period multiplied by process-specific emission reduction factors. Equation 7 is used to determine the avoided GHG emissions resulting from utilizing biomass for electricity generation.

Equation 7: GHG Benefit from Utilizing Biomass for Electricity Generation

$$GHG_{EG} = \frac{\sum_i \left(AGB_{CTCC,\ EC,\ i} \times Q_{EC,\ i}\right) \times 0.25 + \sum_i \left(AGB_{CTCC,\ EG,\ i} \times Q_{EG,\ i}\right) \times 0.32}{2000}$$

Where,			Units
GHG_{EG}	=	GHG benefit from utilizing biomass for electricity generation	MT CO_2e
$AGB_{CTCC,EC,i}$	=	Aboveground biomass of project tree i at time of removal to be utilized for electricity generation via combustion (dry weight from the CTCC)	lb
$Q_{EC,i}$	=	Quantity of removed trees with the characteristics of tree i to be utilized for electricity generation via combustion	trees
0.25	=	Emission reduction factor for combustion	MT CO_2e/ BDT
$AGB_{CTCC,EG,i}$	=	Aboveground biomass of project tree i at time of removal to be utilized for electricity generation via gasification (dry weight from the CTCC)	lb
$Q_{EG,i}$	=	Quantity of removed trees with the characteristics of tree i to be utilized for electricity generation via gasification	trees
0.32	=	Emission reduction factor for gasification	MT CO_2e/ BDT
i	=	Removed project tree to be utilized for electricity generation	
2000	=	Conversion factor from lb to bone dry ton (BDT)	lb/BDT

E. GHG Benefit of Preventing the Landfilling of Biomass

The avoided GHG emissions from preventing the landfilling of biomass and instead utilizing biomass for wood products or electricity generation is calculated as the sum of the biomass diverted from landfills over a 10 year period multiplied by an emission factor for green waste. Equation 8 is used to determine the avoided GHG emissions from preventing biomass from entering landfills.

Equation 8: GHG Benefit from Preventing the Landfilling of Biomass

$$GHG_L = \left(\frac{\sum_i \left(AGB_{CTCC,\ WP,\ i} \times Q_{WP,\ i}\right)}{907} + \frac{\sum_i \left(AGB_{CTCC,\ EC,\ i} \times Q_{EC,\ i}\right) + \sum_i \left(AGB_{CTCC,\ EG,\ i} \times Q_{EG,\ i}\right)}{2000} \right) \times 0.21$$

Where,			<u>Units</u>
GHG_L	=	GHG benefit from preventing the landfilling of biomass	MT CO_2e
$AGB_{CTCC,WP,i}$	=	Aboveground biomass of project tree i at time of removal to be utilized for wood products (dry weight from the CTCC)	kg
$Q_{WP,i}$	=	Quantity of removed trees with the characteristics of tree i to be utilized for wood products	trees
$AGB_{CTCC,EC,i}$	=	Aboveground biomass of project tree i at time of removal to be utilized for electricity generation via combustion (dry weight from the CTCC)	lb
$Q_{EC,i}$	=	Quantity of removed trees with the characteristics of tree i to be utilized for electricity generation via combustion	trees
$AGB_{CTCC,EG,i}$	=	Aboveground biomass of project tree i at time of removal to be utilized for electricity generation via gasification (dry weight from the CTCC)	lb
$Q_{EG,i}$	=	Quantity of removed trees with the characteristics of tree i to be utilized for electricity generation via gasification	trees
i	=	Removed project tree to be utilized	
907	=	Conversion factor from kg to short ton	kg/ton
2000	=	Conversion factor from lb to short ton	lb/ton
0.21	=	Emission reduction factor	MT CO_2e/ ton

F. GHG Emissions from Project Implementation

Tree planting projects must account for GHG emissions from tree planting, maintenance, and other tree-related activities. The GHG emissions from implementation of tree planting projects are calculated by deducting 5% of the annual reductions obtained through carbon storage and avoided emissions from energy savings. Equation 9 is used to determine the GHG emissions from implementation of tree planting projects.

Equation 9: GHG Emissions from Tree Planting Project Implementation

$$GHG_{PI} = (GHG_{CSC} + GHG_{CSI} + GHG_{ESC} + GHG_{ESI}) \times 0.05$$

Where,			Units
GHG_{PI}	=	GHG emissions from tree planting project implementation	MT CO_2e
GHG_{CSC}	=	GHG benefit from carbon stored in live project trees estimated using the CTCC (from Equation 1)	MT CO_2e
GHG_{CSI}	=	GHG benefit from carbon stored in live project trees estimated using i-Tree Streets (from Equation 2)	MT CO_2e
GHG_{ESC}	=	GHG benefit from energy savings estimated using the CTCC (from Equation 3)	MT CO_2e
GHG_{ESI}	=	GHG benefit from energy savings estimated using i-Tree Streets (from Equation 4)	MT CO_2e
0.05	=	Emission factor for project emissions	%

The process and transportation emissions associated with tree removal in an urban wood and biomass utilization project are excluded from this quantification methodology because the trees to be utilized are trees that would be removed and transported to a landfill without the project. Process emissions at a mill or biomass facility are factored into the emission reduction factor for these activities.

G. Net GHG Benefit

The net GHG benefit from any project is the sum of the carbon stored in planted trees, emission reductions from energy savings, carbon stored long-term in wood products, and avoided GHG emissions from utilizing biomass for energy generation of biomass energy, less the GHG emissions associated with the implementation of the project. Equation 10 is used to determine the net GHG benefit from urban and community forest projects.

Equation 10: Net GHG Benefit

$$GHG = (GHG_{CSC} + GHG_{CSI} + GHG_{ESC} + GHG_{ESI} + GHG_{WP} + GHG_{EG} + GHG_{L}) - GHG_{PI}$$

Where,			Units
GHG	=	Net GHG benefit from the project	MT CO_2e
GHG_{CSC}	=	GHG benefit of carbon stored in live project trees estimated using the CTCC (from Equation 1)	MT CO_2e
GHG_{CSI}	=	GHG benefit of carbon stored in live project trees estimated using i-Tree Streets (from Equation 2)	MT CO_2e
GHG_{ESC}	=	GHG benefit from energy savings estimated using the CTCC (from Equation 3)	MT CO_2e
GHG_{ESI}	=	GHG benefit from energy savings estimated using i-Tree Streets (from Equation 4)	MT CO_2e
GHG_{WP}	=	GHG benefit of carbon stored in wood products (from Equation 6)	MT CO_2e
GHG_{EG}	=	GHG benefit from utilizing biomass for energy generation (from Equation 7)	MT CO_2e
GHG_{L}	=	GHG benefit from preventing the landfilling of biomass (from Equation 8)	MT CO_2e
GHG_{PI}	=	GHG emissions from tree planting project implementation (from Equation 9)	MT CO_2e

Appendix B. CTCC List of Species Codes

Table 14 provides a list of 20-30 species for each climate zone included in the CTCC. If the species to be planted by the project are not available options in the CTCC, applicants can choose the species from the same climate zone with the most similar mature size and growth rate. To assist in determining the most appropriate selection of the available species within the CTCC, applicants can use the i-Tree Streets & STRATUM Species Codes by Climate Region reference document available at: http://www.itreetools.org/streets/resources/Streets Species Codes.xls.

Table 14. CTCC List of Species Codes

Climate Zone 1 - North/Central Coast			Cimate Zone 2 - South Coast		
Sp code	**Botanic name**	**Common name**	**Sp code**	**Botanic name**	**Common name**
ACME	*Acacia melanoxylon*	Black acacia	CACI	*Callistemon citrinus*	Lemon bottlebrush
ACPA	*Acer palmatum*	Japanese maple	CEDE	*Cedrus deodara*	Deodar cedar
CICA	*Cinnamomum camphora*	Camphor tree	CESI3	*Ceratonia siliqua*	Algarrobo europeo
EUGL	*Eucalyptus globulus*	Blue gum eucalyptus	CICA	*Cinnamomum camphora*	Camphor tree
FRVE	*Fraxinus velutina*	Velvet ash	CUAN	*Cupaniopsis anacardioides*	Carrotwood
GIBI	*Ginkgo biloba*	Ginkgo	EUFI81	*Eucalyptus ficifolia*	Redflower gum
LIST	*Liquidambar styraciflua*	Sweetgum	FIMI	*Ficus thonningii*	Indian laurel fig
LITU	*Liriodendron tulipifera*	Tulip tree	JAMI	*Jacaranda mimosifolia*	Jacaranda
MAGR	*Magnolia grandiflora*	Southern magnolia	LIST	*Liquidambar styraciflua*	Sweetgum
PHCA	*Phoenix canariensis*	Canary Island date palm	MAGR	*Magnolia grandiflora*	Southern magnolia
PHDA4	*Phoenix dactylifera*	Date palm	MEEX	*Metrosideros excelsus*	New Zealand Christmas tree
PIBR2	*Pinus brutia*	Turkish pine; East Mediterranean pine	MEQU	*Melaleuca quinquenervia*	Paperbark
PICH	*Pistacia chinensis*	Chinese pistache	PHCA	*Phoenix canariensis*	Canary island date palm
PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine	PHDA4	*Phoenix dactylifera*	Date palm
PIRA	*Pinus radiata*	Monterey pine	PIBR2	*Pinus brutia*	Turkish pine; East Mediterranean pine
PIUN	*Pittosporum undulatum*	Victorian box	PICA	*Pinus canariensis*	Canary Island pine
PLAC	*Platanus hybrida*	London planetree	PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine
PRCE	*Prunus cerasifera*	Cherry plum	PIUN	*Pittosporum undulatum*	Victorian box
PYCA	*Pyrus calleryana*	Callery pear	PLAC	*Platanus hybrida*	London planetree
PYKA	*Pyrus kawakamii*	Evergreen pear	POMA	*Podocarpus macrophyllus*	Yew podocarpus
QUAG	*Quercus agrifolia*	Coast live oak	SCTE	*Schinus terebinthifolius*	Brazilian pepper
ROPS	*Robinia pseudoacacia*	Black locust	TRCO	*Tristaniopsis conferta*	Brisbane box
SESE	*Sequoia sempervirens*	Coast redwood	WARO	*Washingtonia robusta*	Mexican fan palm
ULAM	*Ulmus americana*	American elm			
ULPA	*Ulmus parvifolia*	Chinese elm			
WARO	*Washingtonia robusta*	Mexican fan palm			

Climate Zone 3 - Inland Empire		
Sp code	**Botanic name**	**Common name**
BRPO	*Brachychiton populneum*	Kurrajong
CICA	*Cinnamomum camphora*	Camphor tree
EUSI	*Eucalyptus sideroxylon*	Red ironbark
FRUH	*Fraxinus uhdei*	Evergreen ash
FRVE	*Fraxinus velutina 'Modesto'*	Modesto ash
GIBI	*Ginkgo biloba*	Ginkgo
JAMI	*Jacaranda mimosifolia*	Jacaranda
LAIN	*Lagerstroemia indica*	Common crapemyrtle
LIST	*Liquidambar styraciflua*	Sweetgum
LITU	*Liriodendron tulipifera*	Tulip tree
MAGR	*Magnolia grandiflora*	Southern magnolia
PHCA	*Phoenix canariensis*	Canary Island date palm
PHDA4	*Phoenix dactylifera*	Date palm
PIBR2	*Pinus brutia*	Turkish pine; East Mediterranean pine
PICA	*Pinus canariensis*	Canary Island pine
PICH	*Pistacia chinensis*	Chinese pistache
PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine
PLAC	*Platanus hybrida*	London planetree
PLRA	*Platanus racemosa*	California sycamore
PYCA	*Pyrus calleryana*	Callery pear
QUAG	*Quercus agrifolia*	Coast live oak
QUIL2	*Quercus ilex*	Roble negro
SCMO	*Schinus molle*	California peppertree
SCTE	*Schinus terebinthifolius*	Brazilian pepper
WARO	*Washingtonia robusta*	Mexican fan palm

Cimate Zone 4 - Central Valley		
Sp code	**Botanic name**	**Common name**
ACSA1	*Acer saccharinum*	Silver maple
BEPE	*Betula pendula*	European white birch
CESI4	*Celtis sinensis*	Chinese hackberry
CICA	*Cinnamomum camphora*	Camphor tree
FRAN_R	*Fraxinus angustifolia 'Raywood'*	Raywood ash
FREX_H	*Fraxinus excelsior 'Hessei'*	Hesse ash
FRHO	*Fraxinus holotricha*	Moraine ash
FRPE	*Fraxinus pennsylvanica*	Green ash
FRVE	*Fraxinus velutina*	Velvet ash
GIBI	*Ginkgo biloba*	Ginkgo
GLTR	*Gleditsia triacanthos*	Honeylocust
KOPA	*Koelreuteria paniculata*	Goldenrain tree
LAIN	*Lagerstroemia indica*	Common crapemyrtle
LIST	*Liquidambar styraciflua*	Sweetgum
MAGR	*Magnolia grandiflora*	Southern magnolia
PHCA	*Phoenix canariensis*	Canary Island date palm
PHDA4	*Phoenix dactylifera*	Date palm
PIBR2	*Pinus brutia*	Turkish pine; East Mediterranean pine
PICH	*Pistacia chinensis*	Chinese pistache
PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine
PIRA	*Pinus radiata*	Monterey pine
PITH	*Pinus thunbergiana*	Japanese black pine
PLAC	*Platanus hybrida*	London planetree
PYCA_B	*Pyrus calleryana 'Bradford'*	Callery pear 'Bradford'
PYKA	*Pyrus kawakamii*	Evergreen pear
QUIL2	*Quercus ilex*	Roble negro
WARO	*Washingtonia robusta*	Mexican fan palm
ZESE	*Zelkova serrata*	Japanese zelkova

Climate Zone 5 - Desert		
Sp code	**Botanic name**	**Common name**
ACFA	*Acacia farnesiana*	Sweet acacia
ACSA3	*Acacia salicina*	Willow acacia
BRPO	*Brachychiton populneum*	Kurrajong
CEFL	*Parkinsonia florida*	Blue paloverde
CHLI	*Chilopsis linearis*	Desertwillow
EUMI2	*Eucalyptus microtheca*	Coolibah tree
FRUH	*Fraxinus uhdei*	Evergreen ash
FRVE	*Fraxinus velutina*	Velvet ash
MOAL	*Morus alba*	White mulberry
OLEU	*Olea europaea*	Olive
PAAC	*Parkinsonia aculeata*	Jerusalem thorn
PHCA	*Phoenix canariensis*	Canary Island date palm
PHDA4	*Phoenix dactylifera*	Date palm
PIBR2	*Pinus brutia*	Turkish pine; East Mediterranean pine
PICH	*Pistacia chinensis*	Chinese pistache
PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine
PIEL2	*Pinus eldarica*	Afghan pine
PIHA	*Pinus halepensis*	Aleppo pine
PRCH	*Prosopis chilensis*	Algarrobo
QUVI	*Quercus virginiana*	Live oak
RHLA	*Rhus lancea*	African sumac
ULPA	*Ulmus parvifolia*	Chinese elm
WAFI	*Washingtonia filifera*	California palm
WARO	*Washingtonia robusta*	Mexican fan palm

Climate Zone 6 - Mountains		
Sp code	**Botanic name**	**Common name**
ACPL	*Acer platanoides*	Norway maple
ACSA1	*Acer saccharinum*	Silver maple
ACSA2	*Acer saccharum*	Sugar maple
CEOC	*Celtis occidentalis*	Northern hackberry
FRAM	*Fraxinus americana*	White ash
FRPE	*Fraxinus pennsylvanica*	Green ash
GLTR	*Gleditsia triacanthos*	Honeylocust
GYDI	*Gymnocladus dioicus*	Kentucky coffeetree
ILOP	*Ilex opaca*	American holly
MA2	*Malus sp.*	Apple
MAGR	*Magnolia grandiflora*	Southern magnolia
PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine
PINI	*Pinus nigra*	Austrian pine
PIPO	*Pinus ponderosa*	Ponderosa pine
PIPU	*Picea pungens*	Blue spruce
POSA	*Populus deltoides ssp. monilifera*	Plains cottonwood
PR	*Prunus sp.*	Plum
PY	*Pyrus sp.*	Pear
QUMA1	*Quercus macrocarpa*	Bur oak
QUNI	*Quercus nigra*	Water oak
TIAM	*Tilia americana*	American basswood
TICO	*Tilia cordata*	Littleleaf linden
ULAM	*Ulmus americana*	American elm
ULPU	*Ulmus pumila*	Siberian elm

Climate Zone 7 - Northeast		
Sp code	**Botanic name**	**Common name**
ACPL	*Acer platanoides*	Norway maple
ACRU	*Acer rubrum*	Red maple
ACSA1	*Acer saccharinum*	Silver maple
ACSA2	*Acer saccharum*	Sugar maple
AEHI	*Aesculus hippocastanum*	Horsechestnut
FRPE	*Fraxinus pennsylvanica*	Green ash
GIBI	*Ginkgo biloba*	Ginkgo
GLTR	*Gleditsia triacanthos*	Honeylocust
ILOP	*Ilex opaca*	American holly
JUVI	*Juniperus virginiana*	Eastern red cedar
LIST	*Liquidambar styraciflua*	Sweetgum
MA2	*Malus sp.*	Apple
MAGR	*Magnolia grandiflora*	Southern magnolia
PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine
PIST	*Pinus strobus*	Eastern white pine
PLAC	*Platanus hybrida*	London planetree
PRSE2	*Prunus serrulata*	Kwanzan cherry
PYCA	*Pyrus calleryana*	Callery pear
QUPA	*Quercus palustris*	Pin oak
QUPH	*Quercus phellos*	Willow oak
QURU	*Quercus rubra*	Northern red oak
SAPA	*Sabal palmetto*	Cabbage palmetto
TICO	*Tilia cordata*	Littleleaf linden
TITO	*Tilia tomentosa*	Silver linden
ULAM	*Ulmus americana*	American elm
ULPA	*Ulmus parvifolia*	Chinese elm
ZESE	*Zelkova serrata*	Japanese zelkova

Climate Zone 8 - Temperate Interior West		
Sp code	**Botanic name**	**Common name**
ACPL	*Acer platanoides*	Norway maple
ACSA1	*Acer saccharinum*	Silver maple
ACSA2	*Acer saccharum*	Sugar maple
CASP	*Catalpa speciosa*	Northern catalpa
CR	*Crataegus sp.*	Hawthorn
FRAM	*Fraxinus americana*	White ash
FRPE	*Fraxinus pennsylvanica*	Green ash
GLTR	*Gleditsia triacanthos*	Honeylocust
ILOP	*Ilex opaca*	American holly
JUNI	*Juglans nigra*	Black walnut
LIST	*Liquidambar styraciflua*	Sweetgum
MA2	*Malus sp.*	Apple
PIED	*Pinus edulis*	Pinyon pine
PIPU	*Picea pungens*	Blue spruce
PISY	*Pinus sylvestris*	Scotch pine
PLAC	*Platanus hybrida*	London planetree
PLOC	*Platanus occidentalis*	American sycamore
PYCA	*Pyrus calleryana*	Callery pear
QURU	*Quercus rubra*	Northern red oak
ROPS	*Robinia pseudoacacia*	Black locust
TIAM	*Tilia americana*	American basswood
ULPU	*Ulmus pumila*	Siberian elm

Climate Zone 9 - Pacific Northwest		
Sp code	**Botanic name**	**Common name**
ACMA	*Acer macrophyllum*	Bigleaf maple
ACPL	*Acer platanoides*	Norway maple
ACRU	*Acer rubrum*	Red maple
ACSA2	*Acer saccharum*	Sugar maple
BEPE	*Betula pendula*	European white birch
CABE_F	*Carpinus betulus 'Fastigiata'*	Columnar hornbeam
CADE2	*Calocedrus decurrens*	Incense cedar
CRLA80	*Crataegus laevigata*	Smooth hawthorn
FASYAT	*Fagus sylvatica 'atropunicea'*	Purple leaf beech
FRLA	*Fraxinus latifolia*	Oregon ash
ILOP	*Ilex opaca*	American holly
LIST	*Liquidambar styraciflua*	Sweetgum
MOAL	*Morus alba*	White mulberry
PHCA	*Phoenix canariensis*	Canary Island date palm
PHDA4	*Phoenix dactylifera*	Date palm
PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine
POTR2	*Populus balsamifera ssp. trichocarpa*	Black cottonwood
PRCEKW	*Prunus cerasifera 'Thundercloud'*	Thundercloud purple plum
PRSE2	*Prunus serrulata*	Kwanzan cherry
PSME	*Pseudotsuga menziesii*	Douglas fir
PYAN	*Malus angustifolia*	Southern crabapple
PYKA	*Pyrus kawakamii*	Evergreen pear
QUAG	*Quercus agrifolia*	Coast live oak
QURU	*Quercus rubra*	Northern red oak
TIAM	*Tilia americana*	American basswood
TICO	*Tilia cordata*	Littleleaf linden
ULAM	*Ulmus americana*	American elm
WARO	*Washingtonia robusta*	Mexican fan palm

Climate Zone 10 - Interior West		
Sp code	**Botanic name**	**Common name**
CHLI	*Chilopsis linearis*	Desertwillow
ELAN	*Elaeagnus angustifolia*	Russian olive
EUGL	*Eucalyptus globulus*	Blue gum eucalyptus
EUMI2	*Eucalyptus microtheca*	Coolibah tree
FRAM	*Fraxinus americana*	White ash
FRAN2	*Fraxinus angustifolia*	Raywood ash
FRPE	*Fraxinus pennsylvanica*	Green ash
FRVE	*Fraxinus velutina*	Velvet ash
GLTR	*Gleditsia triacanthos*	Honeylocust
ILOP	*Ilex opaca*	American holly
KOPA	*Koelreuteria paniculata*	Goldenrain tree
MA2	*Malus sp.*	Apple
PHCA	*Phoenix canariensis*	Canary Island date palm
PHDA4	*Phoenix dactylifera*	Date palm
PICH	*Pistacia chinensis*	Chinese pistache
PIED	*Pinus edulis*	Pinyon pine
PINI	*Pinus nigra*	Austrian pine
PIPO	*Pinus ponderosa*	Ponderosa pine
PISY	*Pinus sylvestris*	Scotch pine
PLAC	*Platanus hybrida*	London planetree
POAN	*Populus angustifolia*	Narrowleaf cottonwood
POFR	*Populus fremontii*	Fremont cottonwood
PRCE	*Prunus cerasifera*	Cherry plum
PYCA	*Pyrus calleryana*	Callery pear
ULPU	*Ulmus pumila*	Siberian elm
WARO	*Washingtonia robusta*	Mexican fan palm

Climate Zone 11 - Coastal Plain		
Sp code	**Botanic name**	**Common name**
ACRU	*Acer rubrum*	Red maple
BUCA	*Butia capitata*	Jelly palm
CAIL	*Carya illinoinensis*	Pecan
CELA	*Celtis laevigata*	Sugarberry
COFL	*Cornus florida*	Flowering dogwood
GLTR	*Gleditsia triacanthos*	Honeylocust
ILOP	*Ilex opaca*	American holly
JUVI	*Juniperus virginiana*	Eastern red cedar
LAIN	*Lagerstroemia indica*	Common crapemyrtle
LIST	*Liquidambar styraciflua*	Sweetgum
MAGR	*Magnolia grandiflora*	Southern magnolia
PHCA	*Phoenix canariensis*	Canary Island date palm
PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine
PITA	*Pinus taeda*	Loblolly pine
PLOC	*Platanus occidentalis*	American sycamore
PYCA	*Pyrus calleryana*	Callery pear
QULA2	*Quercus laurifolia*	Laurel oak
QUNI	*Quercus nigra*	Water oak
QUPH	*Quercus phellos*	Willow oak
QUVI	*Quercus virginiana*	Live oak
SAPA	*Sabal palmetto*	Cabbage palmetto

Climate Zone 12 - Midwest		
Sp code	**Botanic name**	**Common name**
ACNE	*Acer negundo*	Boxelder
ACPL	*Acer platanoides*	Norway maple
ACRU	*Acer rubrum*	Red maple
ACSA1	*Acer saccharinum*	Silver maple
ACSA2	*Acer saccharum*	Sugar maple
CEOC	*Celtis occidentalis*	Northern hackberry
FRAM	*Fraxinus americana*	White ash
FRPE	*Fraxinus pennsylvanica*	Green ash
GIBI	*Ginkgo biloba*	Ginkgo
GLTR	*Gleditsia triacanthos*	Honeylocust
ILOP	*Ilex opaca*	American holly
MA2	*Malus sp.*	Apple
MAGR	*Magnolia grandiflora*	Southern magnolia
PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine
PINI	*Pinus nigra*	Austrian pine
PIPO	*Pinus ponderosa*	Ponderosa pine
QUNI	*Quercus nigra*	Water oak
QUPA	*Quercus palustris*	Pin oak
QURU	*Quercus rubra*	Northern red oak
TIAM	*Tilia americana*	American basswood
TICO	*Tilia cordata*	Littleleaf linden
ULAM	*Ulmus americana*	American elm
ULPU	*Ulmus pumila*	Siberian elm

Climate Zone 13 - Lower Midwest		
Sp code	**Botanic name**	**Common name**
ACPL	*Acer platanoides*	Norway maple
ACRU	*Acer rubrum*	Red maple
ACSA1	*Acer saccharinum*	Silver maple
ACSA2	*Acer saccharum*	Sugar maple
CASP	*Catalpa speciosa*	Northern catalpa
CECA	*Cercis canadensis*	Eastern redbud
CEOC	*Celtis occidentalis*	Northern hackberry
FRAM	*Fraxinus americana*	White ash
FRPE	*Fraxinus pennsylvanica*	Green ash
GLTR	*Gleditsia triacanthos*	Honeylocust
ILOP	*Ilex opaca*	American holly
JUNI	*Juglans nigra*	Black walnut
MA2	*Malus sp.*	Apple
MAGR	*Magnolia grandiflora*	Southern magnolia
MO	*Morus sp.*	Mulberry
PHCA	*Phoenix canariensis*	Canary Island date palm
PHDA4	*Phoenix dactylifera*	Date palm
PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine
PINI	*Pinus nigra*	Austrian pine
PIPU	*Picea pungens*	Blue spruce
PIST	*Pinus strobus*	Eastern white pine
PODE	*Populus deltoides*	Eastern cottonwood
PYCA_B	*Pyrus calleryana 'Bradford'*	Callery pear 'Bradford'
QUIL2	*Quercus ilex*	Roble negro
QURU	*Quercus rubra*	Northern red oak
TICO	*Tilia cordata*	Littleleaf linden
ULPU	*Ulmus pumila*	Siberian elm
WARO	*Washingtonia robusta*	Mexican fan palm

Climate Zone 14 - South		
Sp code	**Botanic name**	**Common name**
ACRU	*Acer rubrum*	Red maple
ACSA1	*Acer saccharinum*	Silver maple
ACSA2	*Acer saccharum*	Sugar maple
BENI	*Betula nigra*	River birch
COFL	*Cornus florida*	Flowering dogwood
ILOP	*Ilex opaca*	American holly
JUVI	*Juniperus virginiana*	Eastern red cedar
LA6	*Lagerstroemia sp.*	Lagerstroemia
LIST	*Liquidambar styraciflua*	Sweetgum
MA2	*Malus sp.*	Apple
MAGR	*Magnolia grandiflora*	Southern magnolia
PHDA4	*Phoenix dactylifera*	Date palm
PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine
PIEC	*Pinus echinata*	Shortleaf pine
PITA	*Pinus taeda*	Loblolly pine
PR	*Prunus sp.*	Plum
PRYE	*Prunus yedoensis*	Yoshino flowering cherry
PYCA	*Pyrus calleryana*	Callery pear
QUAL	*Quercus alba*	White oak
QUNI	*Quercus nigra*	Water oak
QUPH	*Quercus phellos*	Willow oak
QURU	*Quercus rubra*	Northern red oak
SAPA	*Sabal palmetto*	Cabbage palmetto
ULAL	*Ulmus alata*	Winged elm
WAFI	*Washingtonia filifera*	California palm

Climate Zone 15 - Tropical		
Sp code	**Botanic name**	**Common name**
BABL	*Bauhinia x blakeana*	Hong Kong orchid tree
CAEQ	*Casuarina equisetifolia*	Ironwood
CAIN4	*Calophyllum inophyllum*	Kamani
CANE33	*Cassia x nealiae*	Rainbow shower tree
CISP2	*Citharexylum spinosum*	Fiddlewood
COERA2	*Conocarpus erectus var. argenteus*	Silver buttonwood
CONU	*Cocos nucifera*	Coconut palm
COSU2	*Cordia subcordata*	Kou
DERE	*Delonix regia*	Royal poinciana
ELOR2	*Elaeodendron orientale*	False olive
FIBE	*Ficus benjamina*	Benjamin fig
FIDE6	*Filicium decipiens*	Fern tree
ILPA2	*Ilex paraguariensis*	Paraguay-tea
LASP	*Lagerstroemia speciosa*	Giant crapemyrtle
MEQU	*Melaleuca quinquenervia*	Paperbark
PHDA4	*Phoenix dactylifera*	Date palm
PIBR2	*Pinus brutia*	Turkish pine; East Mediterranean pine
PICO5	*Pinus contorta var. bolanderi*	Bolander beach pine
PIRA	*Pinus radiata*	Monterey pine
PISA2	*Samanea saman*	Monkeypod
SWMA	*Swietenia mahogani*	West Indian mahogany
TAAR	*Tabebuia aurea*	Silver trumpet tree
TACH	*Tabebuia ochracea subsp. Neochrysantha*	Golden trumpet tree
TAPA	*Tabebuia heterophylla*	Pink tecoma
VEME	*Veitchia merrillii*	Manila palm

Climate Zone 16 - Central Florida		
Sp code	**Botanic name**	**Common name**
ACRU	*Acer rubrum*	Red maple
CICA	*Cinnamomum camphora*	Camphor tree
ERJA	*Eriobotrya japonica*	Loquat tree
JUSI	*Juniperus virginiana var. silicicola*	Southern redcedar
KOEL	*Koelreuteria elegans*	Chinese raintree
LAIN	*Lagerstroemia indica*	Common crapemyrtle
LIST	*Liquidambar styraciflua*	Sweetgum
MAGR	*Magnolia grandiflora*	Southern magnolia
PIEL	*Pinus elliottii*	Slash pine
PLOC	*Platanus occidentalis*	American sycamore
PRCA	*Prunus caroliniana*	Carolina laurelcherry
QULA2	*Quercus laurifolia*	Laurel oak
QUSH	*Quercus shumardii*	Shumard oak
QUVI	*Quercus virginiana*	Live oak
SAPA	*Sabal palmetto*	Cabbage palmetto
SYRO	*Syagrus romanzoffiana*	Queen palm
THOR	*Platycladus orientalis*	Oriental arborvitae
TRSE6	*Triadica sebifera*	Tallowtree
ULPA	*Ulmus parvifolia*	Chinese elm
WARO	*Washingtonia robusta*	Mexican fan palm